

Meeting Summary: Solar Panel Recycling Commission

May 24, 2021 1:30 pm – 3:30 pm

Attendees

DEP: Dan Clark (DC), Karen Kloo (KK), Scott Brubaker (SB), Nick Baier (NB), Nick Nader (NN), Celia Chee-Wah, Celia (CC), Ashia McRae (AM)

Non-DEP: Jim Entwistle (JE) -via phone, Dunbar Birnie (DB), Joseph Ferrante (JF), Dr. Stephanie Lee (SL), David Thompson (DT), Lyle Rawlings (LR), Chris Gulics (CG), **Echo Environmental**-Tommy McGuire, (TM) Towns Garner (TG), Michael Harbert (MH), **Cascade Eco Minerals** Curtis Spivey (CS), Chris Stearns (C. Stearns)

DCA: Sean Thompson (ST)

The following is a detailed summary of the discussion and is not a word-for-word transcript. The purpose of the summary is to capture ideas expressed by the Commission members.

KK opens meeting. Reminds attendees of recording. Requests attendees to announce their names when asking questions to presenters. Introduces guest speakers. Explains the charge of Solar Panel Recycling Commission.

Attendee introduction. Description of point of interest.

KK turn over presentation to TM, President-Echo Environmental.

TM: I'm president of Echo, presenting Towns Garner and Michael Harbert, two of our strategic and business development folks are on call too. If I have to leave, they will take over. Towns is new he comes from a different side of the business where has was out working with groups staffing solar. Michael will give you a brief overview.

MH: Hello, I'm Senior Director of Business Development at Echo Environmental and primarily spending a lot of time the last 3, 4, 5 years bringing solar recycling to the industry and looking at new ways to bring that recycling program fully sustainable.

TM: Yes, so we got a presentation . This is an initial slide talking about what we're doing today. We're going to hit some highlights of solar today. It sounds like people are well-versed in the makeup of modules, we'll hit on that a little bit. The key will be focusing on our recycling processes. I know you have Cascade on here, they're another great group. Everybody does things kind of differently and we're all looking as an industry to find ways to do a better job in recycling, these modules. Because they're going to become a big problem. Echo Environmental is R2 certified, which is great. It's a responsible recycling certification and I just spent the last six months with a group of individuals, a lot of different segments of solar, talking about adding solar into R2, similar to electronics and having it recycled and documented in a way under the R2 standard. We're hopeful that solar will get included into the R2 certification as a focus material and something that needs to be tracked by all R2 companies.

DC: I work in E-waste, and we deal a lot with companies that are R2, or E-steward certified or both. If there was a reason, R2 over E-stewards, I would be curious to hear that, to know now those work together or not and where they're at, in terms of solar, if that is something that you can comment on briefly.

TM: Sure, we are not E-steward effectively, we'll write into our contracts that if somebody got something in regard to E-steward that they like. But really, from a high-level, in regard to not utilizing prison labor or not burning anything, these are kind of the only differences within the certifications, and we don't do any of those. E-steward has a much smaller footprint of compliance there are maybe less than 100 and there are I believe, close to 1,000 R2 certified. The thing that's nice is that there is a big network and with R2 what happens is you got some aggregators who are R2 certified and follow all of the R2 guidelines and if they're not a high-level processor like we are, they then ship their product downstream to a certified R2 group whose doing that processing. So, it just kind of creates that responsibility of if you are gathering solar panels or some types of electronics and you're R2 certified, they need to go to a downstream that's actually processing them that's R2 certified, and so there would be a lot more options for solar panel recycling throughout the U.S. if R2 had it within its standard and was tracking it as opposed to right now. In all honesty, an R2 certified company can take solar panels and throw it in the trash. It's not categorized anywhere in their guidelines as to what needs to be done with it. So, it would be nice if R2 were to address that and ensure that it is managed the same way as a circuit board or battery.

DC: Thank you. We deal with the opposite end-it's good to know and I appreciate it.

TM: Our agenda consists of an overview of solar construction 101, crystalline vs. thin film. Our special recycling process-which everybody's got something they do differently, us being a primary recycler of electronics. We've got a unique mouse trap on how we address the recycling of the solar panels, sustainable products from PV, why it's important and the benefits and question and answer, however you guys want to do that. Next slide please.

We have three types of solar panels: mono and poly-which are similar. The mono, you're going to see in more commercial scale projects, it's more effective, but more costly. Poly-you're going to see more so in residential projects. These two types of modules can be recycled by us, and then you have the thin film, which is in its own category because of the contents regarded in it.

So, there's mono-crystalline and poly-crystalline solar cells. As you can see, they look very similar besides the star shape in the middle. But when you're looking at your typical crystalline solar panels and non-thin film panel, this is the kind of look you're seeing and that is typically on all residential and small commercial projects. And then a lot of the larger utility-scale projects as well.

Basic Construction. There's aluminum frame tempered glass, encapsulant, solar cells, and the backsheet, which is polyvinyl fluoride and the junction box, and some wires. So, the way these were put together they're difficult for you to go in and get each one of these levels extracted. There are some machines and technologies I've seen out there but they're relatively slow and a lot of times it can be difficult to find strong reuse in some of these areas, but we are working towards getting a commodity-by-commodity basis. But right now, we're more focused on three or four main parts of the solar panel module for recycling. So that's just the basic makeup of a crystalline module.

On the thin film, they don't use the silicon wafer material on the crystalline units. There's a tin lead solder or something that runs through them that connects all the cells and the thin film is more flexible and has a different makeup. Unfortunately, it's much more hazardous elements in it. With your mono or poly crystalline, you've got a little bit of lead and silver and things like that similar to the make-up of a circuit board make-up, but the thin film have things like cadmium, telluride, copper, indium, gallium, all of these types of things. So usually, you're going to see these products from a single manufacturer for solar and they actually got their own recycling and take-back process built in both because of the hazardous aspects; and because they're able to capture back some of that cadmium and telluride to be utilized back into their systems. Traditionally when we were talking about recycling the poly and mono crystalline units, it's not these thin film units. The construction of thin film is pretty much the same. They don't have the aluminum around them, around the edging and so that's kind of how you can tell the difference between a thin film and poly-crystalline or mono-crystalline units. So that aluminum is usually a pretty good indicator of which unit is coming through.

So, for our recycling process, we actually remove the aluminum. A lot of times folks just throw them into a big shredder. I've found that to be different because you're going to end up with shards of glass and things like that coming off of the aluminum; and a lot of stuff gets lost in the process. Imagine a big auto shredder-there's so many chutes and directions things can go. So we actually cut off the wiring, remove the junction box, and then we have a pressing process actually punching out the glass so we have a pretty clean aluminum product and the remaining PV is shredded down to a small particle size-sometimes twice for some level of glass separation and then it goes into a granulation, where more of the glass is removed out and we're left with a kind of that wafer backing combination with a little bit of glass in it. But our goal is to get as much clean glass as we can and then the balance of that product is kind of a fluff. It's got this silicon, silver, plastic backing. The nice thing is we're one of the larger recyclers in the country. We've got a lot of low-grade circuit boards that are going to smelters and so we're able to blend in that backing product to go to the smelter. It dilutes a little bit the value of the electric circuit boards that we're refining but we could make sure that if there's any rare or precious metals or anything. I know that within it, it will get captured and if you were to just send that byproduct by itself to the smelter, there'd be a number of charges because there's not going to be any payable precious metals. Because of our ability to refine all of these circuit boards we can manage some of this non-glass product that we come up with. We are looking at ways to get further separation of the backsheet and the silicon and metals and things like that. It's a fairly technical process and we're happy with the way we're processing it now and we're always looking to expand upon it.

So, these are the type of things when you get a clean glass product could be made into: foam insulation that goes into homes, abrasives, reflective paint, building products. So, the fact that our wire is being chopped and sent to a wire processor, or aluminum is being removed and going to aluminum mill, the

glass that we can get pure enough is going to a glass facility and the balance is going to be processed at a refinery. Nothing from the circuit boards ends up as a waste. A lot of folks end up pulling off the aluminum and throwing the rest in the trash. We're pretty proud of the fact that we've developed a process that can manage front to back all of the processing of the unit.

Our processing goal is 100% recycling. Maximize residual, minimize risk to environment by keeping products out of landfills, also minimizing risk of industry as a whole. You got manufacturers, folks who have large industrial utility sites. The last thing you want is a 60-minutes like there was eight to ten years ago with electronics-how they were piling up overseas-it's very counterproductive to the solar mission to be landfilling this product. There is a cost associated with it and it has to be taken into account. We think its critical that folks realize that there's about to be a large swath of this stuff coming offline and there needs to be folks like us & Cascade that are ready to manage it.

So why is it important? Last year, 35 million were installed, which all reach end-of-life at some point and that's not including the hundreds of millions of panels that were already in place in US today. Currently, 90% of solar panels end up in landfills, where like E-waste, they eventually leach toxic chemicals into groundwater supply. By 2050, the waste from solar panels will make up 10% of total E-waste worldwide. Ten percent doesn't seem like a big number, but when you think about electronics that's pretty incredible that one item could make that up; and we find studies that do show these thin film units are not properly managed. 62% of that cadmium can leak into the ground and water supply if they're not disposed of in hazardous landfill or processed properly within only a year's time. It's really important on those thin films to have those properly managed and recycling.

Benefits of Solar Reuse. Over the next 30 years, there's a play for the parts and pieces. Michael (Harbert) found something where it's an estimated \$35B in value could be produced as much as 630gw of electricity in newer modules just from parts and pieces.

Maintaining green energy should continue to be a positive for the protection of the environment. Refurbishing offers the ability to expand a sustainable, solar panel presence in developing countries. The problem is, you get a tax credit right now if you're putting in solar panels. You get a tax credit on the whole kit and kaboodle and so if you're putting them on a big, indoor roof like we've got (a 200 sq. ft. facility)-if we put solar panels on there and also a new roof to it, I believe, you see that tax credit on the entire project. So, it could be different at times to get reuse as exciting as new solar because the pricing of solar modules have dropped quite drastically, and the output is pretty strong. And when you get that tax credit it make it different and so it's kind of a double-edged sword on the reuse side because we do a lot of cellphones, laptops, desktops, cable boxes, modems, hard drives. We're always looking for resale if our customer allow it on those products, so that they're not having to make new products out of new commodities and new metals and things like that. So, reuse is always better than recycle, but the reuse market is somewhat different around solar modules especially domestically because of the tax benefits and things like those. It makes it hard to any type of competitive advantage on the resale like we do with cellphones and laptops. And that's about it, any questions?

SL: Thanks for the presentation. How much value would be added if you could remove the backsheet before crushing? Do you see that potentially adding a lot more?

TM: I believe any type of clean plastic or backsheet that we can get usually has a home on the resale side. There are companies that are paying over virgin prices of plastic to get some portion of reusable within. Being able to get a clean backsheet off, not knowing exactly the markets, you'd have to talk to our engineering guys. But I believe that getting the backsheet off would absolutely be a help because I think that we would be able to potentially it's clear and you can just peel it off. We could probably granulate those, put them through our plastics process and reintroduce them to the solar manufacturing world if nothing else; and it also decreases the dilution of what we're sending to be smelted overseas through our smelter in Japan. I would only see removal of a backsheet as a net positive.

SL: Okay, thank you.

MH: Tommy, if I could interject, I will say this real quick to Stephanie. The issue with the backsheet is the fluorite too. Being able to reduce or eliminate the fluorite from that particular backsheet so that it could be reused will be key as well.

SL: So, because the fluorite is there you cannot use it right now?

MH: I believe that is the case.

JF: What is the percentage of the market with the thin film PVs?

TM: Michael, Towns....do you have an idea? Like I said, all your residential folks are going to have non-thin film and the Cascade guys might know this one. Any idea, Michael?

TG: I can interject here. It really kind of depends on what market you're looking at. Tommy just alluded to you-got your residential, commercial, and utility. The utility is harvesting energy and selling that. So, most of what we see or have seen, I don't have an accurate percentage, so I'm not going to say that. There are quite a few sites that are building with thin film and there's really only one manufacturer with that you see producing that, which is First Solar. I would say that the majority of the market is going to be mono and poly crystalline and there are several manufacturers producing those. So definitely more than half but gaining speed towards that number.

LR: To give a New Jersey perspective on that, I don't have our figures but with my personal knowledge of what's going on in NJ., I would say there is some amorphous silicon from early, early on, very small numbers and a little bit of First Solar-again, in pretty small numbers, I would say in total, probably not more than a couple of tenths of a percent that is non-silicon in NJ today. I would say that the thin film is losing share in NJ. Silicon is quite dominant.

AM: How can we verify that information that Lyle just shared? That the installation rates in NJ for the thin film, cadmium, and silicon and these hazardous waste panels? What would be a starting point to verify or confirm the installation amounts in NJ is that low?

LR: The amorphous silicon, as I said, is extremely small and a lot of that is from a local NJ manufacturer that I'm very familiar with. There wouldn't be very much if any hazardous material in the amorphous silicon so really the focus would be on the copper and indium, the First Solar, I mean virtually all the C-I-G has been First Solar and cadmium telluride. I'm unaware of any. So, I think verification would be primarily running down what First Solar has built in the state, which I believe to have been a couple of projects of any size that we should be able to easily identify. Possibly in the monthly installation reports that come out of NJ Clean Energy site every month, those are easily available on the web. If it's not easily identified in there, that'll be a half hour job to identify them. If not, it should be possible to run down those couple of First Solar installs pretty easily.

TM: I think that's the right path to go. First Solar is not really doing any residential stuff, so you just need to see if any First Solar utility scale projects have been in NJ and that should answer the question.

AM: Thank you.

CG: One thing we deal with is determining waste characterization. So, from a hazardous waste versus non-hazardous waste category, I know that reading through your literature and your quals that you guys do not accept hazardous waste. So, our challenge is determining the different manufacturers and types of panels, what may be hazardous versus non-hazardous. We've done some testing at PSE&G that I can't say was done in accordance with RCRA requirements but just for our own knowledge. We had a lot of panels come up very high in lead concentration, above hazardous concentrations. So just curious what do you guys do from a quality assurance/quality control standpoint to ensure the waste you're receiving is not a RCRA hazardous waste?

TM: Michael can speak to that. We've done TCLPs on the product that we're receiving in. But go ahead, Michael.

MH: One of the things we look at is that this is a big issue, Chris across the country. It's been dealt with out in California, they literally classify it as a Universal Waste (UW), and it really is up to the generator at that particular point to make that determination currently because of the requirements in most states. There is no real regulation on what a solar panel is going to be classified, so in many cases, most of our customers look at it like it is electronic waste and that it would fall under electronic waste exempt, and we do capture those metals from our process so we're ensuring that the lead does not make it to any kind of landfill or can be leached into the groundwater or cause ground contamination, etc.

TM: Yes, because there are electronics, circuit boards, and things like that that probably have higher lead concentrations than others and some might be higher than the standards. But because they've got a UW exemption, they kind of all fall into the same bucket. I know it's not a great answer, but we do receive old products that still has mercury on it or lead and things like that. It's just kind of an aggregation of all the products and looking at it as a whole; and then when you have to deal with those certain items as long as your team is well-versed; and knows how to properly identify them and ensure that they're properly managed.

CG: Thank you. Just one different question, but along the same lines. So we looked at other options initially for panels. Looked at hazardous secondary material options for getting rid of these because right now we dispose of them as hazardous waste. EPA requirements, they use the term legitimate recycling, which has the receiver of the material looking at your downstream facilities and creating an audit program to ensure that their product is actually being used as a replacement for other products, not essentially majority of any verification of your downstream receivers and do you have an audit program to ensure the material they're receiving is being reused and not disposed of.

TM: Yeah, so we only go directly to aluminum mills, glass mills or to primary copper smelters. So you're talking about Mitsubishi, one of the largest copper smelters in the world. None of our downstreams-all of our downstreams are the final processor. That's where R2 gets interesting. If you're an R2 certified company, it's important as to why you can send to non-R2s, but it's easier to send to an R2 because you know that their downstreams are vetted and regulated and so this big funnel kind of comes down to is where we are the actual final processor/shredder/destroyer here in the U.S. to get those commodities and we're going to those final mills directly. So there's no downstream liability with our products going to these final multi-billion dollar refiners and things like that.

CG: Ok, thank you. That's all I have.

KK: Anybody else have any questions?

NN: I have couple of general questions. To Tommy, you do have well-established, reliable end markets for glass in Texas, is that what you're saying?

TM: Yes

NN: What happens to the 1% heavy metals content in those solar panels? You said you send them to two smelters?

TM: Yes, like the silver and things like that.

NN: Yes

TM: Yes, that gets co-mingled into our circuit board shred and we're sending hundreds of thousands if not millions of pounds of circuit boards every month. We work with large companies managing their assets on an ongoing basis that are end-of-life. We're an electronics recycler at our core. But those materials get co-mingled to go to those smelters capturing that.

NN: Are your operations subject to any specific environmental regulations in Texas where you are?

TM: That's why we have the R2 certification. The TCQ (Texas EPA) for stormwater and all those good things there is a typical building. But we have different ISO & R2 certification that we hold that exceed anything required by the state.

NN: Do you have any interest in setting up a facility in NJ?

TM: Possibly.

NN: What would be your conditions for that?

TM: I don't know, we would probably have to fight with Cascade to see which one of us does it. But no, absolutely, that we'd be of interest and happy to look at that.

NN: Thank you.

KK: From what states do you receive solar panels? Are there certain states where you can receive panels from and certain states you cannot?

TM: We receive from all across the country.

KK: When you say your R2 certification exceeds the state standard-the state recycling standards? The state hazardous waste standard? State solid waste standard? Under what regulatory scheme do you operate under?

TM: When I say it exceeds the state standard, it has what it classifies as UW, HW, SW, those type of things. Electronics things like that, so our R2 certification every year we are audited to look at the downstream and processing of every type of product. Every pound, mass balance that comes to our facility. The state isn't coming in and auditing us in regard to our recycling, our processing, or anything

like that because we are not a hazardous waste facility and so I just mean there's a lot more scrutiny on us due to the R2 certification than anything from the state.

KK: The analogous example in NJ is E-waste. Our authorized recyclers are required to be R2 certified, or e-Steward certified. But we also have an E-waste statute and regulations specific to E-waste. Also considering UW in NJ. Under what statutory/regulatory umbrella does your facility fall on the state level?

TM: I think it is general recycling. In Texas, you can be an electronics recycler and you don't have to be R2, so I don't know if that's different in NJ.

KK: Yes, that is different and again, we have a specific electronic waste management statute and implementing regulations.

TM: Yes, they don't have that in Texas, you can open a warehouse and take in electronics and not have to be R2 certified, but if you are R2, then obviously you have to send to an R2. Sounds like you guys have stronger regulations, we try to adhere to the top regulations we can set for ourselves beyond anything the state mandates.

KK: Right. So that's kind of one of the questions we're struggling with in NJ is: there's only the one state that has started managing solar panels as UW. Washington state has an EPR. But other than that, I'm not aware of too many states tackling solar panels specifically in their recycling stream and partly because there's no regulatory structure to do that. So, this commission's mission is to establish that statutory or regulatory structure or private sector action to manage the materials. As far as TCLP sampling-do you sample per manufacturer type that comes in or how do you determine your sampling frequency?

TM: We just looked at manufacturer type and go off of that and if we see some new end of the stream, we'll address that.

KK: And do you see a difference with aluminum frame, specifically or even with circuit boards, that the older panels have more lead than newer panels or is there any kind of general statement to be made like that and how do we find out more specifics about that?

TM: We work with a decent amount of manufacturers and so we can dig around and ask for some of that information to get back to you. They're definitely utilizing less things like silver and lead in the process similar to circuit boards because there are other alloys that are cheaper and the connectivity works as well so the need to utilize more experienced, more hazardous items has been reduced by other aluminums and things like that. So coppers and what not, but I'm sure that Michael can get you to some answers on lead, older items versus newer items. I know the silver content is definitely decreasing, but in regard to anything on the hazardous side, what that looks like, we'll get back to you.

MH: That's correct. I'll be happy to get that information to you. One of the things that you also see in solar modules is that the wire that they string between the cells tend to be solder plated. So that's where you get your lead content for the most part. But in some cases, they're starting to use a lead free solder plating on that copper wire and so, you won't see that lead moving forward. But this not every case so yeah, it'll be from manufacturer to manufacturer in many cases.

CG: To expand on that, that wire is embedded in the structure itself, where that goes into your grinding operation, correct?

MH: That is correct.

CG: I think it was Tommy, you stated before you are relying on the generator to make the determination of hazardous versus non-hazardous waste prior to the shipment to you? There's not really a verification that you guys do while the materials is received?

TM: Unless it's thin film versus crystalline.

CG: Okay, got it.

TM: But we do do that verification upon receiving.

CG: Thank you.

KK: Any other questions. Thank you for your time and informative information. Cascade can begin their presentation now.

C. Stearns: Hello everyone. Thank you to Echo for leading the way and doing some of the hard parts of the basics of this process because so much of what we do has quite a bit in common. But I'm going to focus more on what we do that's a little bit different just for the sake of everybody involved. So, I'm Chris Stearns, National Sales Director for Cascade Eco Minerals. I began in the industry about 15 years ago and basically, I started out in manufacturing for solar roof mounts and kind of gradually got into the distribution world. So I've sold quite a few solar arrays in my time and really, my experience is that my management has basically ignored this recycling question. Basically, these modules have 25-year life span has management looking at how they can make money now and not so much what happens to these modules down the road. It's always been a question of mine that really has started to be addressed since I took this role on and now, I work for my boss, Curt Spivey. Curt, please introduce yourself.

CS: Chris Spivey-President of Cascade Eco Minerals. I have 30 years' experience in recycling of all kinds of mediums and engineered many systems to process electronics. Michael Harbert and I worked together for a number of years at a previous company. Cascade is company I started with one of the largest glass recyclers in America. Because it's a product, obviously solar is 85% glass. So, we operated our system across the country to handle solar and it's very similar to a windshield which we have thousands of tons of windshields. Some of the differences is you have polyvinyl urethane in the windshield and a solar laminate, its EVA, and backsheeting, and the rest. So, we'll get more into the separation process and how we process. Largely the difference in what we do is we are in the glass business and since this particular electronic product is 80-85% glass, we re-mineralize this back into a raw material for manufacturing. For our customers, we make raw material chemistry compositions for the likes of Corning & Guardian and people that make glass products and so this is a chemistry that we use with other glass chemistry. All glass has its own chemistry, and our facilities are like giant chemistry compounding facilities; and we have tremendous capacity and Chris will get into a little bit of that in our presentation. I'll let Chris take it over from here.

C. Stearns: Thanks, Curt. Touching on some of what Curt already touched on, I think the biggest difference is the focus in terms of Eco versus what Cascade is doing. We're a glass processor, we're a solar division of one of the largest glass processors in the country. So, what Dlubak/Cascade have done is we devised different methods to approach different waste streams of glass. Curt already touched on windshields, we've regularly processed CRT monitors, construction glass, you name it. Construction glass, we're processing this material at our facilities, last year we did 500,000T of glass processing. My management team, including Curt, sees this potential to pull in all of this glass in the form of the solar modules which are anywhere depending on the construction 75-85% glass, it's a tremendous source of raw material for us. To add into these mineral blends that Curt touched on earlier and so if we're able to capture that we're also able to capture all these other materials in that process. The aluminum frames that we remove Eco does, the junction boxes, the wires, all that comes out in the process; and it sounds like, based on what I've seen of their presentation that our process for actually taking the rest of the module apart is quite similar. Just again, the focus is different what our downstream partners are buying from us as the name implies are the mineral blends that can be then used as basically source material to produce new glass products. So, whether it be fiberglass installation, or sheet glass that's actually used in construction or new module manufacturing to create really that true circular economy. We're creating these mineral blends by recombining the solar glass that we're achieving from this recycling process with all of these waste streams of glass. Now to touch on some of the certifications. We actually have some of the same or if not, identical certifications to Eco in that we are R2 certified and ISO build on top of both state and federal requirements regarding recycling and R2 is seen as really as the de-facto standard for recyclers in the E-waste, glass processing worlds. They hold themselves to a higher standard and we've been part of those conversations with R2s, specifically, about how there might be a more applicable standard to solar recycling as a way to further differentiate ourselves from some of the other companies in this market is to have that extended R2 certification. But, in any case, we are sticking to those and we're processing these modules again, from all over the country for different reasons. But right now, the much of what we see is weather event related. We see hailstorms, we see high wind events are creating projects for us and what we're hoping for is how we might be able to better set up infrastructure. When true end-of-life happens, when these modules are no longer producing energy to justify keeping them in service-what happens to them? Another thing that separates us is that we have locations all over the country including one that actually processing modules as we speak in Upper Sandusky, OH. So, the transit time from NJ to OH, transit costs from NJ to OH, would be inherently less in that case. The next steps for us in terms of what we at Cascade see in how we're approaching this, kind of things like this, is educating the public, educating the stakeholders in the solar industry as to what the status quo is in solar recycling today. Which is to say that (and Tommy touched on this), we

know that a lot of modules are not being recycled. Some are being warehoused or stored, some of them are being landfilled. We know from calling landfills that most landfills in this country will actually take solar modules at the same rate that they would take regular trash and if you call and say you have a pickup of solar modules, they might charge \$80/ton to throw them away. That's certainly an issue. That's what we're constantly fighting against. Again, without belaboring it, that's kind of our premise. 100% landfill free and to use the materials again and in some cases to even make new solar modules, which is really the end game for so many in this industry.

[Presentation by Cascade Eco Minerals begins]

So, these photos are of the Sandusky facility I mentioned earlier. I brought up these photos to show you we have literally, these mountains of glass and various waste streams being created and this facility and as these batches are done, they're each analyzed chemically to see what components we have in them because the solar glass on its own, well, clean solar glass is a good end stream product for us, but on its own it's not really worth very much to our industry partners and we need to use these other sources of glass, their mineral content is able to mix with solar glass and create a useable end stream product for us or for our end partner. So that's what we're really hoping to illustrate here is just how much glass is at this facility to really make it viable for reuse in a recycling process.

Touching on a few other things here. Dlubak-our partners-is a family-owned business they started in the 1930s in their family garage. Different generations of the Dlubaks have come up with different ways and formed different relationships in the industry to get where they are today. These are our locations. The one in the Pacific Northwest is still pending. We're looking at properties in Vancouver and Portland, OR. Vancouver, WA being right across the river from Portland, OR for a facility up there. That's still pending. But these other facilities are active. It's worth noting right now today not all these facilities are actively processing solar modules. But we are retrofitting to add that capability at these locations over the next few years. Right now, our primary facility is Upper Sandusky. We've done a lot of our R&D on this process, but we are opening up other locations.

Going over, we're the last stop. We're where a lot of E-waste companies that are in this industry work with some solar distributor companies. We're the last stop for where those aggregated modules end up. Really, this facility, we're processing automobile windshields, all forms of glass here. Occasionally, we will do just complete production runs, deconstruction runs of these solar modules and again, following the R2 and ISO certifications. It's worth noting that, something that has come up pretty often in the industry, partly because of the role of refurbishment and reuse, which is the first step of solar recycling, but there's sort of this notion that solar modules inherently have value and while that is true, in some cases, especially newer modules coming off younger installations, older solar modules really don't have that much viability in the reuse, refurbishment market; and there is an inherent cost to these processes of taking these modules apart. They're certainly value in the commodities that we take from the process. But they don't really cancel out the cost of recycling. We do have to charge end users something.

The very basic recycling process. We evaluate the modules. Typically, we know beforehand, and I'm confident this is like with Echo and most other recyclers dealing with this work. We know beforehand whether or not they're thin film or crystalline modules. As was discussed earlier, thin film does present an issue in a sense that cadmium telluride is not something that we're able to actively process in our facilities. It's one of the reasons in fact, it's why First Solar has such a robust recycling program of their own. That the product they're selling into the market has this known issue of having these heavy metals involved. So our facility in Upper Sandusky, OH is just down the road from their facility where we process glass that they run through their recycling system after it's washed and deemed to be acceptable to move it out as a non-hazardous waste they send to us for further processing. Essentially, we evaluate each module. We move the modules that are truly at end-of-life for recycling. We recycle them down to their raw materials. Here is a handful of some mid-process solar glass and associated components before our actual mineral sorting step. Then, once it's made into a mineral combination for our end users, it's made into things like this fiberglass installation here on the right.

Basic examples of end markets for us. I actually did not know anything about road beads. It's an interesting and huge market in this country. This nozzle sort of goes between the spray of the paint; and it sprays out these fine spheres of glass that nestle into that top layer of paint. This actually through a process called retro-reflection. This is what's making those lines on the highway so bright when your headlights hit them at night, what you're actually seeing mostly is these glass beads reflecting the color of the line underneath them right back at you. So, we're using a lot of our mineral blends being sold into this industry.

CS: I just want to add that we make our own beads. So, from Cascade Dlubak, we have a division that makes glass beads. So, besides the mineral blends for our downstream partners and customers, we actually make our own different kinds of products, and this is just one of the products that we distribute nationally. It's a big product that we make and so basically, we size the glass, it's softened and then it goes to our factory in Attica, NY where it makes a high-quality product. It's a high demand product. That's all, go ahead Chris.

C. Stearns: This is not the best photo of this, but I didn't want to show anything proprietary. Some of our end users and partners also make fiberglass, whether it's insulation or anything else they might be doing. Whether it's manufacturing or aerospace, our mineral blends work especially well for this. Particularly because they are broken down to this specific size that doesn't interfere with the spinning equipment that makes the fiberglass. So, our end stock material is great for this industry.

CS: I can add a little bit to that, Chris. With a product we've invented a fine grind process that's changed over the fiberglass industry as far as raw material compound. Because of mostly-the organic and high temperature glass-that doesn't work when you're making fiberglass. We provide all the raw material compound for all the largest installation manufacturers in the country, and we've been able to change the chemistry and the sizing of our product; and it's allowed the factories to run at much lower energy costs and much higher efficiency and throughput and saved them thousands of dollars. It's a big advancement in that little area of industry.

C. Stearns: And again, one of these non-proprietary photos. It really illustrates the process that we're separating out those metals primarily from the connections between the solar cells within the solar module and that material is generally a solder-coated copper wire. To really get the most out of it, we work with smelting partners who are able to purify it into the raw different materials, that wire material, and sell it back into the industry as raw commodities. So, I'm just throwing sort of general idea of that process. This is not something we do ourselves, we work with partners on this front here.

Some of our partners, including Guardian and others, are float glass plants. This is their business. They make large sheets of glass. These are actually being sold back into the solar industry in U.S. It's so many companies opened up facilities to make modules here based on the tariffs that were put into place by the prior administration that this has actually become quite a good market for glass in this country to be revised back into solar modules. We're already achieving that circular economy that so many folks in this industry are already talking about.

Touching briefly on our processing capacity and I touched on this prior to presenting. Basically, we process 500,000T of glass in 2020; and part of our whole goal is to increase the amount of raw material we have to ultimately sell on to our customers that buy these industrial blends from us. And so our capacity right now-we're operating several facilities over the coming years and with that in mind, our capacity is essentially unlimited. We can scale as the demand comes in and out right now. We are far ahead of it and we had more materials to process currently. So that's where we're at with processing.

This was actually in a Bloomberg article several years ago. This was recently changed. I found this photo of wind turbines being buried in Casper, WY. Several companies have actually come up with ways to make it possible to recycle these up until recently there wasn't a viable means to take apart these fiberglass wind turbines. The reason I included that here is that all of us are looking at the same thing of how we avoid this blackeye on the renewable energy industry. If potentially, in a few years, as modules come out of the field, they're all filling up landfills or being stored in fields or whatever else. Right now, companies like Echo, companies like Cascade Eco Minerals, have ways to process solar modules and so we're appealing to folks like yourselves, stakeholders, and others in the solar industry end game of processing these modules back into their constituent parts as opposed to seeing what looks like a Tonka truck but what is actually full-size Caterpillar Excavator, burying wind turbine blades in Wyoming. Let's avoid that for the solar industry is kind of my parting message. We're hoping to do that by educating the public and stakeholders in the industry about what's possible today and what we're hoping to do in the future. So that's my presentation. Questions?

KK: Any questions for Chris?

ST: The education you're providing to the public-what does that entail? Who is your audience?

C. Stearns: Basically, what we're doing, I'm approaching state and regional solar energy associations like SEIA. We're partnered with SEIA nationally. There's regional and state groups all across the country and really what we're doing is trying to get in front of their memberships and explain to them what we're doing. Not necessarily give them a hard sale, do this or the world is going to burn. We just want to have

people aware that we are out here and that we are actively recycling solar modules. That's really the education piece and I'm actually going to the Upper Sandusky facility to document the process in video form so that people can actually see it. I myself am very much a visual learner and I think that having people see some of the process will actually go a long way towards that education piece.

KK: Any other questions?

LR: For Cascade and ECM, Chris, you just mentioned you like to partner with industry and industry associations. I'd love to invite both of your companies to address a meeting of our membership and trade association for the Mid-Atlantic region. It's all solar developers and installers and O&M people.

C. Stearns: That'll be great, Lyle. I'll follow up with you about that offline. That's really all we're trying to do. Sure, we want to see potential customers obviously. I wouldn't be here if I wasn't being paid to represent the company. But more than that, I'm really passionate about this. I think it's a really important piece that's been glossed over for so many years. I touched on, in my introduction, that I've been doing this for 15 years and no one has even talked to me about solar recycling until I met and started working for Curt Spivey; and so, I'd love to meet with your members and tell them what we're doing and see what their feedback might be.

LR: Great! Interested in talking offline to set that up.

AM: In your presentation, the one thing our group struggles with is to build a viable recycling program. How do we do that in a responsible way? For instance, we want to avoid having to maintain records, such as requiring manufacturers and installers to register and pay fee and maintaining registries, listings, tracking fees, like in an EPR. In your presentation, you said it is costly to recycle modules. How do we find some way, as you said, to pass those costs onto the consumer/end users? How do we make this so that the people who have the ability to recycle will receive some type of return of investment or profit margin? What suggestions would you offer to that?

C. Stearns: It's important to understand that while there is an inherent cost, I would argue that it's not necessarily very expensive. Right now, the going rate for recycling, I'd say \$15-\$18 per solar module-give or take. It's typically based on weight, that's where the range comes from. Now, as far as how to pass that on to end users, what I've found and really what is sort of the sad thing is that nobody who is making money on solar right now today is very eager to pay for recycling. Whether it's the developer, module manufacturer, the installers, or the end users, no one wants to be saddled with that bill. So, what we work on everyday and what this industry is looking for is the cheapest possible means of responsible module disposal and the only way for us to get there is through investment. The only way to have investment is to make money. So how do we arrive at what is the happy medium here and that is the conversation we're having constantly. We're not eager to give this service away on our own expense. Obviously, we want to see more volume no matter how much is coming through the door. It's a question Ashia, and frankly, I don't have sort of a patent answer for you. I wish that I did. I think that's what we're all here discussing-how do we make this viable for industry.

DC: To backtrack to what you said a minute ago, when you say it's a \$15-\$18 per module, what are you referring to as a module? I guess how big of panel?

C. Stearns: When I think of modules, I typically think of either a 60 cell is the typical designation which is more what people think a residential side solar module or depending on the weight, again a 72 cell module, although most of them are not, most of them are like 144 split cells, but for the sake of conversation, a 72 cell would be commercial size module that's typically what I refer to. The weight range I'm considering is between 40-60 lbs. when I make those calculations.

DC: Ok, so using that, roughly for most residential installations, are you saying that it would cost \$15-\$18 to recycle what covers the whole roof on a house or is that....

C. Stearns: No, no, it's per module. So, if you had a typical residential application, you have say 15 solar modules, you're looking at 15 times \$15 at the bare minimum, would be your cost for recycling. Typically, you're going to end up paying freight as well. So to be fair, it's \$15-\$18 plus freight to the nearest facility for that recycling process to occur.

DC: Ok, so before the freight costs, essentially you would be looking at, give or take, \$300-\$500 or something?

C. Stearns: Give or take. For a typical residential array of a small size, yes, that would be the bulk part you're looking at.

LR: I just did quick math on what we're talking about statewide as of now, we probably have roughly 3600 mw of solar in the ground. You know, if you were to establish an average module size in watts, let's call it 280 or something like that, that give us shy about 13 million modules on the ground right now. So, if you multiply that by the \$15-\$18, you get an idea of the scale of the issue, and I hadn't started thinking about that until you answered those last bits of questions. You know it's going to be a real issue for the solar industry to figure out who's going to foot the bill for the recycling costs if it remains that high. That translates to about six cents a watt. That's really close to being equal to the entire profit of a typical installer to install those solar panel systems. It's going to be pretty tough for the owners to come up with that if the cost stays that high. I would call that a real gating issue-a central problem that we'll be facing.

CS: Right now, we've got a pretty stable investment of expansion of our technology throughout our plants. Certainly, our aim and goal is to make it more affordable. Chris touched on it a little earlier, obviously, that more volume might change that. We're going to be able to get that price down because this product we're making raw materials from it. So, we're early on in this game, but what I have to say that I see where this is going a faster rate than I think people may realize is that Michael [Harbert] and Tommy [McGuire] can agree, I've seen the advancement in technology on solar panels and in just a few short years go from, you're citing an average of 280 watts go to 400 watts and what's happening is this 25 year idea of something is going to last an array for 20 years is not going to happen. There's refreshing going on where you can put in a 400-watt, or bifacial watt, 500-watt panel when just five years ago you installed something at 280 watts and see some of the larger arrays and the technology curve is going so fast that I see a rotation of this product happening sooner rather than what was properly estimated when it was installed.

LR: That may be a good policy for this commission to consider whether policy should encourage not just reuse but keep using. These modules are warranted for 30 years, and they have at least a 35-year lease of life. It would be a waste of resources to start trashing them when they're still producing useful electricity. What you brought up about refreshing/repowering arrays is a very active conversation. Not within the industry but maybe from the point of overall societal policy we should balance the desire to get more power out of less space because we're a very space-constrained state, but balance that with the waste that would occur; and it's wasted investment as well as wasted material. If we do that kind of refreshing. That probably should be a very active discussion and debate.

TM: Yes, I probably see that more with commercial arrays. You're not going to see that with residential, and large utility ground mount projects and things. It is what it is.

LR: Residential use is maybe 30% running into the 40% range in recent years and it's declining and declining again. But overall, over time, maybe 35% of the total. So the rest of that is commercial. So, there's definitely a need to have that policy discussion.

TM: Great. Just wanted to throw that out there. Because what I noticed all electronics, I don't care if they're laptops, cell phones, it's all happening at such a fast pace.

KK: Any other questions?

JF: Who delivers the supply to your facilities? Typically-are they aggregators with large trucks, are they homeowners-what's the breakdown?

CS: Sure, that's a great question. Right now, we see a mixed bag. We partnered with a couple of electrical distributors, including CED, Baywa, who are aggregating modules on behalf of some of their smaller customers for example, like homeowners, contractors who may just have a small crew and then we'll see an aggregated truck come in from them. Really, to save everyone on freight costs, is kind of like the name of the game. We do occasionally work with smaller projects where they have just a few pallets. More often than not, we're trying to get companies to either work with each other or through one of these local. We got an example in Boulder, CO, there's a great recycling facility there that accepts modules on behalf of the public and sends us trucks. So, it's a long way of saying it's a mixed bag, but mostly we're trying to see the largest shipments possible to save freight. We don't benefit from the freight costs.

JF: When you say freight costs, is it typically imposed on the supplier-you're not covering that?

C. Stearns: Very rarely. We have some agreements.

JF: Not F.O.B. shipping points?

C. Stearns: Right, exactly. In most cases, we're putting the responsibilities of freight onto the customers.

JF: Thank you.

CG: I want to be fair to Eco and the questions I asked him too. As far as your quality control/quality assurance relative to the receipt of materials or pallets that could be considered hazardous waste, how do you guys manage that because I assume like the others, you do not accept hazardous waste as part of your authorizations under the federal/state, under RCRA, same thing: if it's up to the generator if there's some quality control/quality assurance sampling that you perform in your house? Just curious if you can answer that?

C. Stearns: Yes, that's a great question. I appreciated if the first time you asked and it's worthwhile to ask it again. Basically, what we're looking for, just in the same vein of Eco, we're trying to identify with the end users that's calling us because they want to recycle. More often than not, we're asking for the brand and model number of those modules; and with that, we've got a databased of hundreds, if not thousands, of data sheets from these manufacturers. Really, we're looking for the thin film. That's the clear indicator that there could be hazardous waste in there. Nine times out of ten, we're able to identify that it's a crystalline solar module that doesn't have (with the exception of potentially some heavy metals) something that we'd be wary of handling. We cannot handle the First Solar cadmium telluride blend, as we touched on earlier. So, to really answer the question, we're working with the end user to determine what they have before it ever gets to a truck and gets shipped to us. Because there's so many implications moving hazardous waste around the country. If that's not done correctly, that causes everybody a problem. So, we have gotten to touch on an extended point here. We have been contacted a lot about broken thin film modules, specifically First Solar modules. They were not able, we were not able to accept them because of the nature they were in Florida, I believe, and would have to have been sent to Ohio on a hazardous waste manifest. So, it's a big issue. I'm talking about moving broken thin film modules right now.

CG: Do you see manufacturers getting behind their own manufacturing knowledge and coming up with some database of as part of the Safety Data Sheets (SDS) to indicate whether their panels would be considered as hazardous waste if damaged or end of life?

C. Stearns: Sure, that's a great question. So, I've not seen it addressed by any module/manufacture. I tried to reach out to First Solar, part of the project is to see what they would like us to do if anything. We really couldn't have done anything with that material and they were in a similar boat. They didn't really know what to tell the customer because it changes things when a module is broken. I've not seen anything official on it from either a manufacturer or state or regulatory group. It's something that really should be discussed. I don't know where to begin with it.

CG: Thank you, Chris.

CS: I just want to add a little bit more to what Chris just said in that regard. We work with most of the domestic manufacturers and have worked with a number of them on TCLP'g and trying to make a SDS from each one of them. Again, we're 50 different countries and they're just worried about their own state where they manufacture. We've done a lot TCLP'g-we're TCLP'd to death and you can punch a corner out of any module out there and pretty much if you strike the tin lead wire, you're going to get a **PP** reading. So, it's really not our concern. But each state again has a threshold on **PP**. But everyone is conscientious of that.

CG: Alright, guys, thank you.

KK: Anybody else have questions?

SL: Chris, the \$15-\$18 per module, that's mostly for the disassembly/removal of the aluminum frame and other parts?

C. Stearns: It's a good question. It's really the whole processing. So, taking a module from what the form was in when it was out in the field down to the various waste streams, whether it be aluminum, the glass, the backsheet-all these things that have to be disassembled. It takes really expensive equipment that's proprietary that breaks down, it takes labor, it takes electricity. So really, it's covering our overhead is the intent of the charge. Certainly, if we could perform this for less, we would. We're trying to come out with a margin that covers our costs with a thin profit margin with the intent being that if we process millions of pounds of material, that thin profit margin will translate to profit.

SL: Would you pay for the glass if, let's say if we did this in-house (the disassembly and separating), would the glass be something you would pay for?

C. Stearns: That's not really something we typically pursue. The glass itself doesn't have a ton of value on its own, we're talking pennies per pound. So, in theory we might, but I think Curt could speak to that better than I could.

CS: With the glass, a lot of people think they can make it clean, but there's a lot to what we do to get the glass to a state where we can then reuse it. I think it's not as simple as "oh we're just going to grind it up". It doesn't quite work that way. We do have a little bit of...there's a lot more that goes into it. As I stated before, though I really have to tell you that we have our goal (and I think we can get there) is to continue to lower our recycling costs. Because we're doing what you're alluding to; and that's being able to have a 100% recycling.

SL: But the solar glass that you recycle-this is the silicon plus the backsheet?

CS: Yes, everything.

SL: But you crush it all together?

CS: Yes, we have each of our systems is about \$6M of equipment. I don't know how to describe that, but it's built, they're huge processing systems, some fairly sophisticated separation processes through it. We have to do that because our end products that we're blending and making have to have that quality.

SL: Thank you.

KK: Anyone else?

DT: Can I ask a hypothetical question?

C. Stearns: Please do.

DT: Apologize if I am off base. I don't fully appreciate the definition of electronics under the UW regs. I was wondering if solar panels just another form of electronics and how regulators at DEP would view that type of question?

C. Stearns: I'm not sure if I understand.

DT: To me solar panels are just another piece of electronics, why isn't it already UW?

C. Stearns: That's a good question. It's a topic that's come up quite a bit with various end users that we work with. Some of these larger companies we do business with are in many states. How to define what regulations we fall under when federal and state regs are very spotty at best in regard to end-of-life solar modules. With the exception of California, no one has really come out and said anything about UW. I think it's really more up to state and federal guidelines to start addressing this because right now, there are not a ton of rules on solar recycling and as Tommy touched on earlier, we could still technically qualify for R2 based on the way we read it. I laughed when he said it: "we could be throwing modules away, we're not". I can say that with confidence. But the rules are very, very scant on solar module recycling. We'd like to see those improved, so that we could further differentiate ourselves.

DT: I guess my question is how precisely defined are electronics under current UW rules? Why isn't the solar panel just another piece of electronics?

C. Stearns: That's a good question. I think....

KK: In NJ, they're very specifically defined as computers, CDs, printers, faxes were added as part of the last law statutory amendments. So, they're very specific. E-Waste in NJ is very specifically defined.

NN: Consumer Electronic Devices (CEDs).

KK: Yes, under the law.

DT: Okay, thank you.

LR: Solar panels are not electronic. They're electric power generation equipment but not electronic. They got no smarts inside them.

NN: They function like a battery.

DT: A circuit board could be considered electronics. It's a piece of equipment.

KK: Nick, did you have a question or comment?

NN: Question for Chris. Would you advise us to impose some sort of surcharge here for a sale of every solar panel in NJ? Dedicated to a recycling fund, would it be advisable in your opinion?

C. Stearns: This is an approach. Granted, take this with a grain of salt because I have a vested interest and I'm making money doing this. I think the best single approach would be to ban the landfill and that will drive companies like Eco and CEM to produce a solution that's viable for your state. Working together on something like that, where it's not cheap and easy to go and throw them in a landfill. That I see as doing more for the industry than an upfront charge, but your mileage may vary on that.

CS: That sounds like a California Advanced Recovery Fee (ARF) model where they charge for displays, screens. It's been a very successful program in California, but it's the only state. It's more similar to WEEE (Waste from Electrical and Electronic Equipment) in Europe or up in Canada. I think it's worked out quite well compared to the EPR model, which I think, is what you guys are contemplating if I'm not mistaken. Of course, Dave, I hear your voice, you know more about this than any other human I know. As far as us comparing what works, I don't know if I really agree at all with how California approached solar, but time will tell.

KK: Lyle, do you have a question or comment?

LR: One thing to be sensitive to, something like a mandate for assessing a fee on module upfront will touch of kind of an inter-agency struggle. Because somewhere else in Trenton, at the BPU, aided by the Regulatory Council's office, they are pushing as hard as one could possibly push to get the cost and incentive down and of course, anything that raises the cost of solar, the cost of the incentives, the state must provide to maintain the projects viable. Right now, at this very moment, that's a mighty struggle between the BPU and solar industry, with the BPU saying we're not going to pay you as much we tell them we need to just meet the minimum rate of return. So, it's mighty battle already. This conversation would need to be part of that conversation really to make things work. The reason I raised my hand is I have an update on the conversation we were having before about First Solar. I found that one of the reports that come out every month from the Clean Energy Program. Among these reports that come out every month is one called Data Equipment Installed. I downloaded the latest one. The report gives a wealth of information about every solar installation in NJ since the beginning. Including the manufacturer of all the equipment, including solar panels and inverters and it's searchable. I was able to search for First Solar, there were more projects that I really realized but most of them are fairly small, only four projects over 1MW and so, I've got totals for you and I'll send out. I've sorted this dataset, there's over 50,000 records but I've sorted it by manufacturer and highlighted in red and bold the First Solar ones. I'll send out to everybody. But long story short, there are a total of 23 projects with First Solar modules, the total is 8.3MW of capacity. That's about .23% of the total NJ capacity and that's 91,404 modules by First Solar. And Chris-to what you we're saying before: one thing we could do is have, because of the fact they're much more hazardous when they're broken, we could have standards for dismantling solar projects in general recommended guidelines or even regulations and with First Solar, that they have to be, or any other thin film that has that materials, that they have to be dismantled and handled with care not to break them and have some sort of requirements and standards in place.

MH: I'll just reiterate and mirror what Chris said in regard to landfill bans. I think that's probably one of the greatest ways and methods of keeping solar modules out of landfills of course; and promoting recycling. You'll always have the issues with those that ship them to the next state and put them in their landfills. I think that's whether you choose a consumer program or extended producer program. Having a landfill ban attached to that as well, I think that would be a huge plus moving forward.

C. Stearns: Thanks, Michael. That's a pretty firm one with the recycling team over here. Don't let them in your landfills.

JF: What we did in NJ with food waste might offer an example. Instead of an outright ban, we said that if there's a facility within x miles of a generator, of a certain level of waste in this case-food waste, it was required to use that facility as opposed to going to a landfill. So, if you had a recycling facility in NJ, you could say theoretically, you are required to use that facility. But there is a cost factor because to satisfy that landfill ban folks, we had to import the notion of parity all things being equal if the costs are the same or better at the facility, you're required to use that facility. So there's an economic calculus to factor in.

KK: Right, but there's already a few, but not many food waste recyclers in the state. This would again be one of those examples of we pass a law, and they will come. There's a certain amount of risk there-what if they don't come?

CC: Chris, I have a 2-part question for you. First one is have you heard of a mineral content called antimony?

C. Stearns: Yes

CC: Ok, that huge pile. This is second part of my question. The huge mound of glass that we saw there-is antimony contained in that huge mound?

C. Stearns: I'm going to defer to Curt on that one. I do not know with confidence one way or the other.

CC: Ok.

CS: And your concern with antimony?

CC: It's a hazardous waste. That mound-is the lining for that mound above ground? Or below ground?

CS: Lining? Are you talking about at the landfill?

CC: No, that mound of glass that we saw there. There's a lining at the bottom of that right?

CS: There is a 12-inch pad of concrete with another 12-inch curb around the entire property of cement. This is compliance captive acreage where all these minerals stay and sit.

CC: Ok, the only reason that was asking is for groundwater. I was just wondering if there's any kind of seepage was going to be going out from that huge pile. How long does that pile stay there for? How often does it come to half?

CS: You'd be surprised. We rotate through that I don't know how many times per year. That's how fast this material comes in and goes out and builds up and goes out. We supply the largest consumers of glass throughout this country daily. We have rail spurs that go into our plants. Material comes in and we have railroad carloads going out. It's moving all the time, it's an everlasting mountain. Good question.

CC: I'm glad to hear that it's a whole bunch of cement under that huge pile.

CS: Absolutely. All of our yards are just like little swimming pools.

KK: So, if no one else has any questions, I have a similar question to what I asked previously as well. So, it looked like your list included nine facilities in 9 different states, one of which is pending. Do all of these eight facilities and you said that some are in the process of being retrofitted to accept solar panels? How many are currently accepting solar panels?

CS: Right now, they all accept solar. They main processing will do sub-assembly and sub-processes at some and for the main processing and re-mineralizing, we have four different plants that do that. It's where we're implementing our fine grain operations and so each facility is outfitted differently like that. But each of them can sub-disassembly and sub-processing before we do final processing.

KK: Ok and the reason I'm asking again, I'm trying to understand the intersection between the R2 standard and the ISO standard and the regulatory requirements or statutory requirements in each of those states. So, again in NJ, we have the E-waste law, which requires R2 certifications for those authorized recyclers managing CEDs. We have a very specific set of regulations managing/overseeing/authorizing/recycling of all kinds of materials in the state. So, I guess I'm still not understanding. Seems like in Texas, there is no regulatory requirements. You don't even need to be R2 certified. So, in the four states that you are processing, are there statutory or regulatory requirements governing these processes.

CS: That would be no. We're in Texas also. Ohio doesn't even have an electronics recycling bill. Which is strange because we're surrounded by every other state that does. I've always found it interesting that Ohio didn't even adopt an electronics recycling bill in R2 certification. We do a lot of CRTs in Ohio. It's a wild west show to be honest with you.

KK: Yes, that is foreign concept here in NJ! Where we have highly regulated activity and very, very prescribed and we often have people who operate these facilities are not real rule followers. So, I've always wondered why they elect to get in this business. So, that was my question and again, forgive my ignorance, I'm just trying to understand for those solar panels that are not thin film panels, there are still hazardous constituents in the wiring and possibly circuit boards in the older panels and the newer panels and how is that managed in relation to RCRA?

C. Stearns: Essentially, there is lead in the solder, in between the connections, and in between the cells. There's no actual circuit board, there's the solar cell itself which are often sputtered, is the name of the

process where there's a fine mist of a deposited C-I-G-S (copper, indium, gallium, selenium). So there are heavy metals included in these materials as far as whether or not they're compliant, we don't tend to run into RCRA rules for them because in general, they're regarded as UW or as general waste. We don't see modules listed as hazardous waste anywhere with the recent changes in California being considered as UW. So, as far as whether or not, I don't know if you can elaborate on this, Curt. I don't think we're running into RCRA regs on the handling of solar panel modules? Am I correct?

CS: No, we don't Chris. I think Chris [Gulics] had asked the question before on lead levels. When we look at this product by itself, outside of the First Solar cadtel problems. All of the wire that is connected to the solar cell material criss crosses throughout the laminate, outside of the bus bar which connects to that. That has a tin lead coating. So that wire is removed. That's where you find your lead level concern or RCRA concern. But it's encapsulated until it comes to our processes, then separated and we take that and we actually have a process to remove that material as well as reuse the copper. It's a very proprietary, unique solution. Anyway, that's the only areas that we found through all of our assays. Because we assay everything in our glass. We deal with a lot of crystal. Crystal is 35% lead, that's why it makes a nice sound when you're playing on a crystal glass or if you ever dropped crystal on the ground, it makes a nice sound. It has a lot of lead in it. As well as the CRT glass we deal with that has 19%-20% lead in the funnel part and about 90% lead in the front of a CRT device. So, when it comes to lead and glass, we've been doing it for years.

KK: We are over our time, and I want to be respectful of everyone's time. Are there any final questions or remarks? Let's pencil in a tentative date for our next meeting. June 21, 2021, same time as usual. At our next meeting, we will review and comment on the draft outline for the final report.